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(71) Applicant: Nichia Corporation

491-100 Oka, Kaminakamachi, Ananshi

Tokushima

(72) Inventor: Yoshinori Shimizu

c/o Nichia Chemical Industries Co., LTD.

491-100 Oka, Kaminakamachi, Anansh

Tokushima

(54) [Invention Title] Planar Light Source

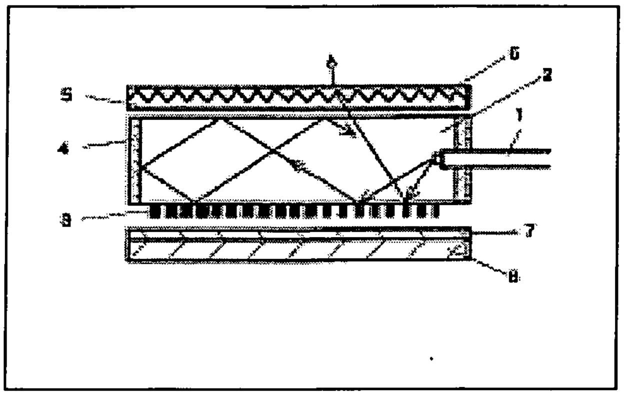
(57) [Summary]

[Purpose]

To realize and provide a planar light source which can provide white light by employing blue light emitting diodes and on which a uniform white emission can be observed.

[Constitution]

Blue light emitting diodes 1 are optically connected to an edge surface(s) of a transparent optical waveguide 2; there is a scattering layer 3 to scatter fluorescence in which white powder is applied on one primary surface of said optical waveguide 2; a transparent film 6 is provided on a primary surface side of optical waveguide opposing said scattering layer 3; and a phosphor which emits fluorescence when it is excited by an emission from said blue light emitting diodes 1 is provided to film 6.



[What is Claimed is:]

[Claim 1]

A planar light source, wherein blue light emitting diodes 1 are optically connected to at least one section of an edge surface(s) of a transparent optical waveguide 2; there is a scattering layer 3 in which white powder is applied on one primary surface of said optical waveguide 2; a transparent film 6 is provided on a primary surface side of optical waveguide opposing said scattering layer 3; and a phosphor which emits fluorescence when it is excited by an emission from said blue light emitting diodes 1 is provided on a surface of or in film 6.

[Claim 2]

The planar light source according to Claim 1, wherein fine bumps are provided on a surface of said film which comes in contact with the optical waveguide.

[Detailed Explanation of the Invention]

[0001]

[Field of Industrial Application]

The present invention pertains to a planar light source which is employed for a backlight of a display, an illuminated switch and the like. In particular, it pertains to a planar light source which can be excellently employed for a backlight of a liquid crystal display.

[0002]

[Conventional Technologies]

EL or cold cathode tube, as an example, is employed as a planar light source for a backlight of a liquid crystal display which is in general utilized in a notebook personal computer and word processor. EL itself is a planar light source. A cold cathode tube utilizes a diffuser plate to form a planar light source. At present, an emission color of most of these backlights is white.

[0003]

On the other hand, light emitting diodes (in general, abbreviated as LED's) are also employed in some light sources for a backlight. When LED's are employed to obtain white emission, however, the emission power of conventional blue LED's is as little as approximately a few tens of micro W. Therefore, it is difficult to match the properties of LED's emitting each color when blue LED's are combined with red and green LED's to realize white emission, and there is a disadvantage in that color variations are large. Moreover, even when LED's for the three primary colors are combined and positioned geometrically at the same positions on the same plane, it is impossible to obtain a uniform white light source for a backlight because LED's are seen from a close distance and each can be recognized. Therefore, under the present circumstances, different sources are utilized for a different application: cold cathode tubes are employed for a white backlight of a large liquid crystal display and EL is employed for a white backlight of a small to medium liquid crystal display. Hardly any white backlight using LED's is known.

[0004]

Moreover, attempts are made in some white or monochromatic light sources to convert color by surrounding a blue LED chip with a resin containing a phosphor. The areas around the chip are exposed to radiation with a larger intensity than that of the solar ray, however, and degradation of phosphor is an issue. In particular, degradation is severe in an organic fluorescent dye. Further, the electrophoresis takes places in an ionic organic dye under an electric field and its color tone may change. Moreover, conventional blue LED's do not have enough power for color conversion through a phosphor and even if color conversion is conducted, practical results are not obtained.

[0005]

[Issues to be Resolved by the Invention]

The present invention was conceived in order to resolve these disadvantages. Its purpose is to realize a planar light source to produce uniform white emission which can

be utilized primarily as a backlight and at the same time, to provide a planar light source on which uniform white emission can be observed. Further, its purpose is to employ the reliable properties of LED's and apply them to various switches and the like.

[0006]

[Means to Solve the Issues]

Claim 1

[0007]

Figure 1 is a top view in which optical waveguide 2 of a planar light source according to the present invention is observed from the side of the second primary surface. Optical waveguide 2 is made of a transparent material such as an acrylic material or glass. Blue LED's 1 are embedded in the edge surface of optical waveguide 2, thereby optically connecting optical waveguide 2 and blue LED's 1. Further, in the present invention, optically connected an edge surface of optical waveguide 2 and blue LED's 1 means introducing light from blue LED's 1 through the edge surface of optical waveguide 2 in simple words, which can be accomplished, for example, by not to mention embedding blue LED's as illustrated in the figure, but also attaching blue LED's with an adhesive, or guiding emission from the blue LED's to the edge surface of optical waveguide 2 using optical fibers and the like.

[0008]

Next, scattering layer 3 uses a white dye to scatter light within optical waveguide 3. Particularly in Figure 1, aforementioned scattering layer 3 is made of stripes and has a pattern in which the surface area occupied with scattering layer 3 per unit surface area of the second primary surface is smaller in a portion to LED's 1 so that the surface brightness across the first primary surface is constant. Further, the occupied surface area over the edge section pf the second primary surface farthest from LED's 1 is slightly smaller than its maximum. Here in the figure, solid squares represent the pattern of scattering layer 3. The structure in Figure 1 has 6 blue LED's which are arranged on one

edge surface. It goes without saying that LED's can be connected on all four edge surfaces if the optical waveguide is rectangular or square. There is no limit on the number of LED's. Further, depending on how LED's are arranged, in what shape and how scattering layer 3 should be applied in order to make the emission observed on the first primary surface planar and uniform can be appropriately altered.

[0009]

[Operation]

Figure is a schematic cross-sectional diagram of a planar light source of the present invention when it is employed for a backlight of a liquid crystal panel as an example. On the second primary surface of the planar light source depicted in Figure 1, a reflecting plate in which a scattering reflection layer 7 made of a material such as barium tananate, titanium oxide and aluminum oxide, and a base 8 made of, for example, Al are stacked is provided. On the first primary surface, a transparent film 6 with a fine bumpy pattern on its surface is provided. On the bumpy surface of film 6, a phosphor which emits fluorescence when it is excited with the emission from blue LED's 1 is applied.

[0010]

As an arrow depicts in Figure 2, some light from blue LED's 1 is emitted outside of optical waveguide 2 in the vicinity of the chips. Most of the light, however, repeats total reflections within optical waveguide 2 and reaches edges of optical waveguide 2. The light reaching the edges is reflected by a reflecting layer 4 which is formed on all edge surfaces and repeats total reflections. At this time, scattering layer 3 which is provided on the second primary surface of optical waveguide 2 scatters the light. Fluorescent layer 5 absorbs part of the scattered light, at the same time, converts its wavelength and radiates fluorescence. Light with an emission color from combining both emissions is observed from the first primary surface of optical waveguide 2. For example, in a case of a planar light source with a fluorescent layer 5 made of a fluorescent dye for orange light, the aforementioned effects enables a white emission to be observed from blue LED's 1.

[0011]

Particularly in the present invention, the primary emission peak from blue LED's needs to be shorter than 500nm and each blue LED needs to have an emission power of 200 microW or larger, more preferably 300 microW or larger, because it is difficult to realize all colors when the emission wavelength is 500nm or longer and there is a tendency in that it is more difficult to obtain a uniform planar light source with sufficient brightness even if more blue LED's are optically connected to edge surfaces of an optical waveguide when each LED has an emission power of less than 200 microW.

[0012]

The present inventor propsed a planar light source which can provide a uniform white emission by forming a scattering fluorescent layer on a primary surface of an optical waveguide opposing a surface through which an emission is observed in Patent Application No. H05-318267. In this method, however, the scattering fluorescent layer which is formed on an optical waveguide must be removed and a scattering fluorescent layer for a desired color tone must be printed in order to change its color tone. In the present invention, however, a fluorescent layer 5 and a scattering layer 3 are independent from each other and in particular, a fluorescent layer 5 which determines the color tone is formed on a film which can be attached and removed. Therefore, merely changing a film on which a fluorescent layer 5 is formed can alter the color tone. Moreover, multiple colors can be separately emitted at once.

[0013]

Furthermore, bumps are formed on the surface which comes in contact with the first primary side of a film 6, and therefore, the bumps are very useful in scattering the emitted light. Moreover, the bumps prevent a film 6 from plastering on an optical waveguide 6, thereby preventing interference bands from appearing.

[0014]

[Embodiments]

[Example 1]

On a surface of an acrylic plate with a thickness of approximately 2mm, a scattering layer 3 was formed with the stripe pattern illustrated in Figure 1, using a screen printing method. A white material made of barium titanate was dispersed in an acrylic binder and scattering layer 3 was printed and formed with the mixture.

[0015]

The acrylic plate on which scattering layer 3 was formed in the manner above was cut to a desired shape and all edge surfaces of the acrylic plate were polished. Then, a reflecting layer 4 made of Al was formed on the polished surfaces. Thus, an optical waveguide 2 on which scattering layer 3 was formed was obtained.

[0016]

Next, on a film 6 on one surface of which bumps were formed, a fluorescent layer 5 was formed. An equal amount of a fluorescent dye for red, FA-001 manufactured by Shinloihi Chemical Co. LTD., and a fluorescent dye for green, FA-005 manufactured by the same company, were mixed and the fluorescent dyes were dispersed in an acrylic binder, which was painted to form fluorescent layer 5.

[0017]

Six holes were made on an edge surface of aforementioned optical waveguide 2. In each hole, a blue LED made of gallium nitride-related compound semiconductors with an emission power of 1,200 microW was embedded. Subsequently, film 6 on which fluorescent layer 5 was formed as above was provided on the emission observation side, and a reflecting plate in which a barium titanate layer 7 was applied on an Al base 8 was provided on the side with scattering layer 3 to prepare a light source for backlight. Then, completely planar and uniform white emission was obtained from the first primary surface. The luminance was 55cd/m^2.

[0018]

[Example 2]

A nearly equal amount of a fluorescent dye for yellow, LumogenF Yellow-083 by BASF, and a fluorescent dye for orange, Orenge-240 by the same company, were mixed. A fluorescent dye in which the mixture and an acrylic resin were dissolved in butylcarbitol acetate was applied on a film 6 on which fine bumps were provided. The rest was performed in the same manner as in Example 1 and a planar light source of the present invention was prepared. Then, nearly uniform planar emission was observed. Further, in the same manner, the light source was employed as a light source for backlight. Then, completely uniform planar emission was observed.

[0019]

[Advantages of the Invention]

As explained above, a planar light source of the present invention employs blue LED's and moreover, there is a scattering layer 3 in which white powder is applied on a primary surface side of an optical waveguide. Further, on the other primary surface side, a transparent film 6 on which a phosphor which can convert the wavelength of emission from the blue LED's is applied is provided. Thus, a planar light source using LED's with excellent reliability can be realized. Furthermore, the white powder in scattering layer 3 has effects to reflect and scatter the emission from the blue LED's and hence, a small amount of the phosphor will suffice. Further, fine bumps are formed on film 6. Thus, the effect to scatter light is enhanced and the film is prevented from plastering on optical waveguide 2 and interference bands are prevented from appearing. To make the matters even better, the LED chips and phosphor do not come into contact with each other. Therefore, the phosphor does not degrade as much and the color tone of a planar light source does not change over a long time period. Moreover, a proper selection of a phosphor in fluorescent layer 5 can provide for any color tone including white. Moreover, the phosphor is provided with the film and therefore, merely replacing the film can alter the color tone of the planar light source.

[0020]

On the other hand, as for the excitation of a fluorescent layer 5, specifying that the blue LED's employed most preferably have an emission power of 200 microW or more

facilitate effective4 wavelength conversion by the phosphor and realization of bright planar light source over a large area. Thus, a planar light source of the present invention can not applied to an illuminated switch and the like, in addition to a light source for backlight.

[Brief Explanation of Figures]

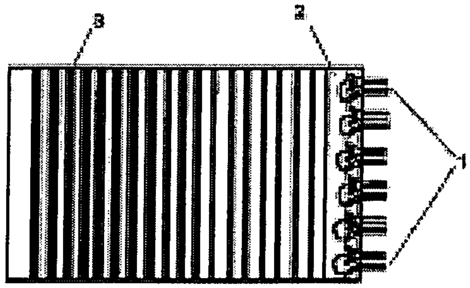
[Figure 1]

A top view when an optical waveguide 2 of an example of a planar light source of the present invention is observed from the side with a scattering layer 3.

[Figure 2]

A schematic cross-sectional diagram when an example of a planar light source of the present invention is assembled as a backlight.

[Figure 1]



[Figure 2]